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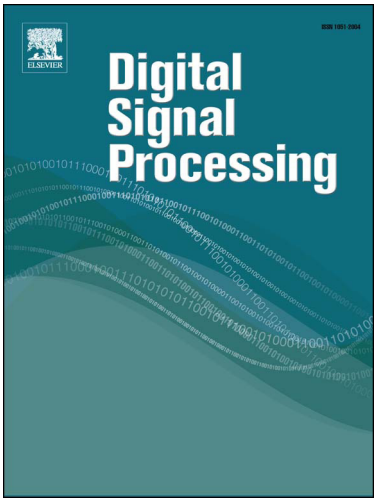

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Image denoising in dual contourlet domain using hidden Markov tree models

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Abstract— **Used in a wide variety of transform based statistical image processing techniques, the hidden Markov tree (HMT) model with Gaussian mixtures is typically employed to capture the intra-scale and inter-scale dependencies between the magnitudes of the transform coefficients. But, the conventional model does not consider the signs of the transform coefficients. In this paper, a new HMT model which exploits mixtures of one-sided exponential densities is used to consider the signs of transform coefficients. The present study has two main contributions: 1) for the first time, HMT with mixtures of one-sided exponential densities is used to denoise images, and 2) a new efficient model formed by two one-sided exponential densities and one Gaussian density is proposed. In addition, the proposed method uses the dual contourlet transform (DCT) which is formed by the combination of the directional filter bank (DFB) and the dual tree complex wavelet transform (DTCWT). This transform is (nearly) shift-invariant and is computationally less expensive than the NSCT (nonsubsampled contourlet transform). Thus, it is fast and efficient when applied to image processing tasks. Experimental results on several standard grayscale images show that the proposed method is superior to some state-of-the-art denoising techniques in terms of both subjective and objective criteria.**

Index Terms—**Hidden Markov tree, Dual contourlet transform, Image denoising, Shift-invariance, Statistical models.**